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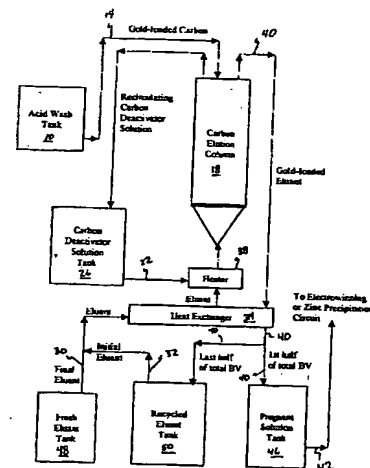
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(54) PROCESSUS D'EXTRACTION DE METAUX D'UN SORBANT
(54) PROCESS FOR REMOVING METALS FROM A SORBENT

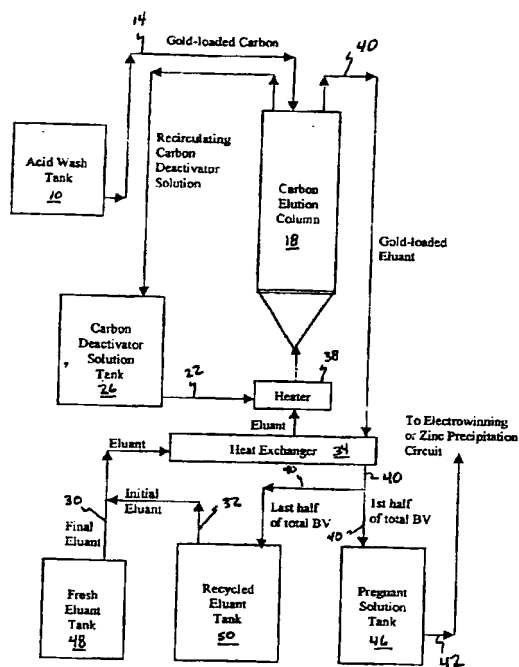
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ABSTRACT

The present invention is directed to an elution or stripping process using a polar solvent and nonpolar blinding agent. The blinding agent can be a hydrocarbon, carbohydrate, ammonia, molecular nitrogen, and mixtures thereof.

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PROCESS FOR REMOVING METALS FROM A SORBENT

FIELD OF THE INVENTION

The present invention relates generally to removal of metals from metal-containing materials and specifically to removal of metals from substrates carrying the metals, such as sorbents.

BACKGROUND OF THE INVENTION

This invention relates to the recovery of precious metals from activated carbon, specifically to an improved elution process.

10 Cyanidation is commonly employed for the extraction of gold from its ores. In this process, the crushed ore is treated with a dilute solution of sodium cyanide (NaCN), and a small amount of lime (CaO) to maintain a pulp pH of ≥ 9 . In the presence of oxygen, gold dissolves forming gold cyanide complex.

Recovery of the gold is accomplished by adsorbing the gold cyanide complex on activated carbon. A variety of processes based on this reaction have been developed. Effectiveness of these processes is, however, dependent on the development of an efficient means of eluting the gold from the gold-loaded carbon.

The most common commercial methods for the elution of gold cyanide from activated carbon are the Zadra (U.S. Patent No. 2,579,531, issued December 25, 1951) and Anglo processes.

20 In the latest Zadra elution process, a hot solution of 1% weight/volume (w/v) sodium hydroxide (NaOH) and 0.2% w/v NaCN are recycled through a gold-loaded activated carbon bed for up to 72 hours at 95-100°C. to elute gold cyanide. A modified Zadra process operating at 140°C. in a pressurized system reduces elution time to 10-12 hours.

In the Anglo elution process, gold-loaded activated carbon is soaked in a solution containing 3-5% w/v NaCN and 1% w/v NaOH followed by elution for 8-12 hours with deionized water at 100-120°C. The eluant solution is not recirculated; therefore, it is a once-through process.

5 The recycling of the weak gold-loaded eluant from the "tail-end" of an elution cycle to the beginning of the next elution cycle is practiced successfully both in the Zadra and Anglo processes. However, in the Zadra, high gold value in the recycled eluant slows down the elution process.

10 While both the Zadra and Anglo processes are effective in eluting gold from activated carbon, these processes suffer from high energy consumption, high capital costs for pressurized operations, and a long elution period. Although, conducting the elution under pressure or modifying the eluant with organic compounds also improves the rate of elution,⁷ these processes are complicated to implement.

15 There have been other attempts to elute gold from activated carbon involving the use of temperatures lower than those used in the Zadra or the Anglo elution process. D.M. Muir tried to elute gold by pretreating gold-loaded activated carbon with a solution of sodium cyanide and sodium hydroxide, and then eluting the carbon with methanol, ethanol, or acetonitrile vapors and condensate at 65-80°C. Using this process, Muir eluted gold cyanide in 4-6 hours. However, the Muir process requires an expensive sealed system to minimize
20 (1) fire hazards of electrowinning due to the flammable organic solvent and, (2) solvent losses due to evaporation.

F. Espiell tried to elute gold from activated carbon using mixtures of NaOH (20 g/L) and 50% aqueous organic solvents at 30°C. Espiell found that this acetone-water-hydroxide method was most efficient at a gold desorption with 90% of the gold being eluted in less than 40 minutes. However, a loss in gold-binding activity resulted over several loading/eluting cycles. This loss resulted from the failure of the acetone solvent system to elute the gold most strongly adsorbed to the activated carbon.

Heinen et al., U.S. Patent No. 4,208,378, tried to elute gold at 70-160°C. with a solution of about 20-30% v/v water soluble alcohol and about 80-70% aqueous solution with a strong base of sodium or potassium hydroxide.

10 Parker et al., U.S. Patent No. 4,427,571, tried to elute gold from activated carbon using at least 20% v/v polar organic solvents or mixture of polar organic solvents, preferably, nitriles containing sodium cyanide or sodium thiocyanate.

Harvey et al., U.S. Patent No. 5,769,925, tried to elute gold by adding a powerful reducing agent, such as hydrazine monohydrate, to standard eluants, such as NaOH/NaCN with or without alcohol.

Belsak et al., U.S. Patent No. 4,968,346, tried to elute gold using an eluant of about 2-3% v/v alcohol and 97-98% v/v deionized water. This approach involves adding to the eluant at least 2.5% w/w of a strong base (sodium or potassium hydroxide) and at least 0.3% w/w sodium or potassium cyanide.

20 Fuller et al., U.S. Patent No. 5,073,354, tried to elute gold using as an eluant a compound containing the carboxylate functionality, selected from benzoic or substituted benzoic acids and polyacrylic acids of less than about 100,000 M.W.

Fisher, U.S. Patent No. 3,935,006, tried to elute gold using, as eluants, water-soluble alcohols or ketones alone or with their aqueous solutions. Adding a strong base of sodium or potassium hydroxide facilitate elution.

In the prior art, sodium cyanide and sodium hydroxide are universally used in the elution process. The importance of these two reagents in the elution process is illustrated numerous studies on the mechanism of adsorption and elution of gold cyanide from activated carbon. Thus, Davidson established that the addition of "spectator cations" could enhance appreciably the gold adsorption following the sequence, $\text{Ca}^{2+} \geq \text{Mg}^{2+} \geq \text{H}^+ \geq \text{Li}^+ \geq \text{Na}^+ \geq \text{K}^+$. He proposed a mechanism involving the adsorption of gold as ion pair $\text{Mn}^+[\text{Au}(\text{CN})_2]_n$, and the use of the cations to preserve electroneutrality as counter ions in the electrical double layer.

According to Van Deventer, the presence of spectator cations (M^{m+}) enhances the formation of $\text{M}^{m+}[\text{Au}(\text{CN})_2]_n$ ion pairs on the carbon, which in turn suppresses the elution of gold cyanide. When the concentration of cations in the eluant is high and cyanide is absent from the solution or the carbon, very little desorption of gold is observed. Free cyanide in the eluant, which causes some competitive adsorption of cyanide with gold cyanide, plays a minor role at the elevated temperatures used in the industry. A more important effect of cyanide is its reaction with functional groups on the carbon, the products of which passivate the surface for adsorption of gold cyanide, with cyanide enhancing the elution of gold cyanide. The degree of passivation, which is determined to a large extent by the temperature of pretreatment, also affects the elution of cations and the degradation/adsorption of cyanide itself.

As the following table shows, conditions that enhance elution hinder adsorption.

Conditions Favoring Adsorption	Conditions Favoring Elution
Low temperatures	High temperatures
Low cyanide concentrations	High cyanide concentrations
Low Alkalinity	High Alkalinity
High ionic strength medium	Low ionic strength medium
Presence of Ca^{+2} , Mg^{+2}	Absence of Ca^{+2} , Mg^{+2}

Jia observed that ethanol and butanol, adversely affect gold adsorption. He also observed that low pH increased adsorption of gold and silver cyanide whereas organic solvents and high temperatures decreased gold and silver adsorption.

In summary, prior methods of eluting gold cyanide from activated carbon called for:

- (a) A high temperature/pressure pre-soak of the loaded carbon with NaCN/NaOH solution followed with hot deionized water;
- (b) A high temperature/pressure elution with aqueous NaCN/NaOH;
- (c) Organic solvents or compounds which contain aqueous NaCN/NaOH; or
- (d) Relatively complex unit operations involving distillation with aqueous NaCN/NaOH, such as the Micron process.

These prior methods had the following disadvantages:

- (i) high energy costs because of elution at high temperatures;
- (ii) lengthy elution period;
- (iii) requirement for high quality water (Anglo process);
- (iv) expensive organic solvents or compounds, or both;
- (v) fire hazards associated with organic solvents; or
- (vi) large volumes of gold-loaded eluant.

Thus, there is a need for a fast, safe, low-temperature, and efficient process for eluting gold cyanide from activated carbon for the recovery of metallic gold from aqueous solutions containing gold cyanides.

SUMMARY OF THE INVENTION

The present invention provides an effective methodology for removing metals and metal complexes, particularly cyano-metal complexes, from substrates, such as sorbents. The methodology is useful in extractive metallurgical processes, such as cyanide extraction of metals from metal ores followed by adsorption onto a suitable media, the treatment of industrial effluents and waste waters, and water purification.

In one embodiment, a method for solubilizing a metal from a substrate (or sorbent) carrying the metal is provided that includes the step of contacting the substrate with a stripping solution containing a nonpolar or substantially nonpolar molecule or blinding agent. The blinding agent displaces the metal from the substrate into the solution.

The substrate or sorbent can be any material that absorbs, adsorbs, and/or entraps the metal or complex containing the metal. In a particularly preferred embodiment, the sorbent adsorbs the metal or metal complex. Preferably, the substrate preferentially absorbs, adsorbs and/or entraps nonpolar molecules compared to polar molecules when present in the same solution. Preferred substrates include activated carbon, polymers, and resins with activated carbon and resins being more preferred.

The process is effective for a variety of metals and metal complexes. Preferably, the metal is a member of any one of Groups VIIIA, IB, or IIB, of the Periodic Table of the Elements. More preferably, the metal is gold, silver, platinum, copper, nickel, cobalt, mercury, and/or mixtures thereof.

The metal can be complexed with a variety of functional groups, including cyanide, thiocyanate, thiosulphate, and mixtures thereof. Typically, the metal is complexed with cyanide.

The blinding agent is preferably a nonpolar or substantially nonpolar molecule or compound that has a molecular size small enough to displace the metal or metal complex on the substrate and that is homogeneous or substantially homogeneous in the solution. Preferred blinding agents include organic compounds such as carbohydrates and hydrocarbons (*e.g.*, compounds including only the elements carbon and hydrogen such as the aliphatic or straight-chain paraffins (or alkanes having the general formula C_nH_{2n+2}), olefins (having the general formula C_nH_{2n}), alkenes, alkadienes, acetylenes, acyclic terpenes, and the cyclic or closed ring alicyclic compounds (*e.g.*, cycloparaffins or naphthenes), cycloolefins, and cycloacetylenes), aromatic compounds (*e.g.*, benzenes, naphthalenes, and anthracenes), and cyclic terpenes (both monocyclic or dipentenenes and dicyclic or pinenes) and inorganic compounds such as ammonia, molecular nitrogen (N_2), and mixtures thereof. Particularly preferred blinding agents have one or more saccharose units or first reaction products of a saccharose unit, such as monosaccharides, (*e.g.*, simple sugars such as fructose (levulose) and its isomer glucose (dextrose) both having the formula $C_6H_{12}O_6$); disaccharides (*e.g.*, sucrose ($C_{12}H_{22}O_{11}$), maltose, cellobiose, and lactose); and polysaccharides (*e.g.*, high polymeric substances).

The ammonia can be added to the stripping solution in many different ways, such as in the form of anhydrous ammonia or as an aqueous solution of ammonia..

The concentration of the blinding agent in the stripping agent can vary. Preferably, the blinding agent has a concentration (before the contacting step) ranging from about 0.1 to about 5 wt.%, more preferably from about 0.2 to about 2 wt.%, and even more preferably from about 0.5 to about 1.5 wt.%.

The stripping solution typically includes a solvent for the blinding agent. To avoid competing with the blinding agent in displacement of the metal or metal complex from the substrate, the solvent preferably is a polar or substantially polar compound. Preferred solvents include water, alcohols, and mixtures thereof.

5 The pH and temperature in the contacting step are important in achieving a high rate of displacement of the metal/metal complex from the substrate. Preferably, the stripping solution has a pH in the contacting step of at least about pH 7 and more preferably ranging from about pH 10 to about pH 11 and a temperature ranging from about 75 to about 125°C, more preferably from about 85 to about 110°C, and even more preferably from about
10 95 to about 97°C.

While not wishing to be bound by any theory, it is believed that the blinding agent is more attracted to the substrate than the metal/metal complex and causes the metal/metal complex to be forced into the stripping solution due to its replacement on the substrate by the blinding agent. In a gold or silver cyanidation recovery process, for example, gold or
15 silver cyanide is adsorbed by activated carbon from a pregnant cyanide leaching solution. The loaded activated carbon is then contacted with the stripping solution. The blinding agent causes a shift in the equilibrium between adsorbed gold/silver and dissolved gold/silver in favor of the dissolution of gold/silver in the stripping solution. For sugar as the blinding agent, calcium, the complexing agent in the gold/silver cyanocomplexes, and
20 magnesium preferentially react with the sugar to form calcium sucate or magnesium sucate, respectively, thereby preventing the calcium from again complexing with the dissolved gold/silver. As noted, the low concentration of magnesium and/or calcium ions favors elution of the metal/metal complex.

The process can have a number of advantages. The process can have low energy consumption, low capital costs, and relatively short elution periods. The process is relatively simple and avoids or eliminates the need for pressurized and/or high temperature operations. The process can use blinding agents and solvents that have low flammability, low toxicity, and are relatively inexpensive. For example, the eluant can be sugar dissolved in water. The process can maintain acceptable levels of metal-binding activity over several loading/eluting cycles. The process can use blinding agents that act effectively, even in the presence of low quality water as the solvent. The process can be highly efficient. The process can elute a high fraction of the metals on the sorbent surface. The eluant can elute (solubilize) even the metals most strongly adsorbed on the sorbent.

In one configuration, the elution efficiency of recycled electrowinning solution is increased by first eluting the carbon with fresh eluant and then with the recycled electrowinning solution. The process can generate low volumes of metal-loaded eluant. For example, passing the eluant twice through fresh carbon can reduce the volume of gold-loaded eluant by 50% (compared to other processes) without sacrificing elution efficiency.

The stripping solution can include a mass transfer agent that is different from the solvent and the blinding agent. The mass transfer agent is a nonpolar or substantially nonpolar molecule. Preferred mass transfer agents include molecular nitrogen, ammonia, and mixtures thereof. In one configuration, the mass transfer agent is in the form of a gas that is sparged through the stripping solution before and/or during the contacting or elution step. The gas, like the blinding agent, displaces the metal/metal complex and causes turbulence in the solution adjacent to the substrate surface, thereby enhancing mass transfer of the metal/metal complex from the substrate surface into the solution.

The pregnant solution generated by displacement of the metal/metal complex on the sorbent will include (a) the blinding agent; (b) the solvent; and (c) the dissolved metal. Typically, the concentration of the dissolved metal in the pregnant solution, after the contacting step, ranges from about 1 to about 5,000 ppm. More typically from about 1 to about 1500 ppm and even more typically from about 5 to about 1000 ppm. The metal is typically recovered from the pregnant solution by electrolytic, cementation or precipitation techniques.

The residue or substrate, after the contacting step, includes the blinding agent and the metal/metal complex. Typically, in the contacting step at least about 90% of the metal/metal complex is displaced into the solution and more typically from about 95 to about 99.5%.

The residue or substrate is regenerated by contacting the substrate with a wash solution having an acidic pH to remove at least most of the blinding agent and form a regenerated sorbent. Preferably, the pH of the wash solution is no more than about pH 3 and more typically ranges from about pH 0.5 to about pH 2. While not wishing to be bound by any theory, at a basic pH (particularly a pH of from about pH 7 to about pH 11) the blinding agent is typically more attracted to the sorbent than the metal/metal complex and will therefore displace the metal/metal complex from the sorbent surface. In the presence of an acidic pH, the blinding agent is at most only weakly attracted to the sorbent surface and will be removed from the sorbent surface.

20

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 shows the major components and flow directions of an elution process according to the present invention;

Fig. 2-A shows the effect of calcium on elution efficiency with or without sugar;

Fig. 2-B shows the elution recovery curve for sugar, sugar/calcium, and without sugar in distilled water and tap water;

Fig. 2-C shows the elution recovery curve of the elution process according to the present invention in relation to the Zadra and Anglo processes;

5 Fig. 2-D shows an improvement over the Zadra process brought about by using sugar/calcium eluant in the first 1.5 BV, 2.25 BV, and then a recycled Zadra eluant;

Fig. 2-E shows the elution recovery curve of an elution process according to the present invention demonstrating the advantage of passing the eluant through fresh carbon twice;

10 Fig. 2-F shows the elution recovery curve of an acid-washed carbon in relation to a non-acid-washed carbon;

Fig. 3 shows the major components and flow directions of the additional embodiment of an elution process according to the present invention.

15 Fig. 4 depicts an elution process according to another embodiment of the present invention;

Fig. 5 depicts an elution process according to another embodiment of the present invention; and

Figs. 6 and 7 plot, respectively, eluted carbon assay vs NaCN concentration and gold concentration vs time.

DETAILED DESCRIPTION

Although the process embodiments discussed below specifically refer to the elution of gold from gold-loaded activated carbon generated from an extractive metallurgical process using a cyanide-containing lixiviant, it is to be understood that the processes are equally applicable for metals other than gold and for processes other than extractive metallurgy. For example, the processes can be used on other precious metals and base metals, to name but a few, and may be used to elute or remove metals/metal complexes from sorbents generated in water treatment and/or purification processes.

10 The Elution Circuit

A first embodiment of a process involving selected major operations is shown in Fig.

1. The process assumes that the metal, which in the embodiment is gold, has been removed from a cyanide lixiviant onto activated carbon by known techniques. The acid-washed, gold-loaded carbon is acid-washed, water-rinsed, and neutralized in the acid wash tank 10.
- 15 The gold-loaded carbon 14 is then transferred to the carbon elution column 18 and preheated to operating temperatures preferably from about 95-98°C by recirculating a hot carbon deactivator solution 22 introduced at the bottom of the column 18. After about one hour at the preferred temperature of about 95-98°C, the carbon deactivator solution 22 is drained back to the carbon deactivator solution tank 26 and can be reused for the next batch of gold
- 20 loaded carbon. Recycled or fresh eluant (or stripping solution) 30 or 32, respectively, is pre-heated in the heat exchanger 34 to a temperature of from about 20 to about 85 °C and further heated to a temperature of from about 95 to about 100°C with 98°C being preferred by a heater 38 before entering the bottom of the carbon elution column 18. The process parameters in the column 18 are set forth above and below. The typical residence

time of the eluant in the column 18 typically ranges from about 30 to about 48 min. The gold-loaded eluant 40 flows out the top of the tank and is cooled down by the heat exchanger 34 before it flows into the pregnant solution tank 46 or the recycled eluant tank 50. From the pregnant solution tank 46, the gold-loaded eluant 42 goes to the electrowinning cells or the zinc precipitation circuit (not shown).

Operation of the Elution Circuit

The operation of the process will now be described with reference to Fig. 1.

As indicated in Fig. 1, the gold-loaded carbon is prepared for elution by acid washing in the acid wash tank 10 at about pH 1 with 3-5% v/v mineral acid solution, such as nitric acid or hydrochloric acid. This pretreatment is meant to: (a) dissolve carbonate scale and reduce levels of silica, magnesium, aluminum, and other metals; (b) reduce overall contaminant levels in the pores of the carbon; and (c) remove grit, wood fiber, plastics and residual slime by screens integrated into the operation. The acid-washed carbon is rinsed with water to remove residual acid solution and neutralized to about pH 10 with minimal amount of sodium hydroxide.

The acid-washed carbon 14 is transferred from the acid wash tank 10 to the carbon elution column 18. The temperature of the carbon is raised to about 95-98°C by recirculating a hot carbon deactivator solution (3-5% w/v NaCN) 22 through the bottom of the carbon column 18 to fluidize the bed of carbon in the column. Recirculating the hot solution 22 through the carbon will: (a) raise the carbon temperature to the desired elution temperature; (b) convert the adsorbed gold on the carbon into an elutable form (i.e., from calcium gold cyanide to sodium gold cyanide); and (c) minimize gold adsorption by the carbon. This step takes about one hour after the carbon has reached operating

temperature of about 95-98°C. The solution 22 is then drained back into the carbon deactivator solution tank 26. If the presence of hydrogen cyanide in the carbon deactivator solution 22 causes concern for safety/environmental reasons, a small amount of ammonium hydroxide may be added.

5 Hot (95-98°C) eluant 32 from the recycled eluant tank 50 and/or fresh eluant tank 48 at about 1.5 to about 2 bed volumes (BV) per hour is passed through the carbon in the carbon column 18 in a fluidized bed configuration to elute the gold from the carbon. The fresh (or final) eluant 30 is prepared in fresh eluant tank 48 by adding about 1% w/w of a blinding agent, preferably sucrose, into commonly available water, such as process water or
10 thickener overflow water from other process operations. Fresh eluant 30 preferably contains about 1% sugar and the recycled eluant sugar concentration may be increased to about 2% by adding sugar into the recycled eluant tank 50. In other words, the recycled eluant 32 typically has a higher blinding agent concentration than fresh eluant 30.

Assuming that the total volume of eluant used in the elution process is about 10 BV,
15 the first 5 BV preferably comes from the recycled eluant tank 50 and the last 5 BV from the fresh eluant tank 48. The first 5 BV of gold-loaded eluant 40 coming out of the carbon elution column 18 preferably goes to the pregnant solution tank 46, and the last 5 BV of gold-loaded eluant preferably goes back to the recycled eluant tank 50. This cycle is repeated with every batch of carbon. By contacting the eluant twice with fresh carbon, the
20 concentration of gold is increased, thereby decreasing the volume of pregnant solution subjected to electrowinning.

At this point, the gold can be recovered from the gold-loaded eluant 42 in the pregnant solution tank 46 by known techniques, such as zinc precipitation or electrowinning.

The recycled eluant 40 in the recycled eluant tank 50 typically contains from about 100-200 ppm gold in contrast to a Zadra solution, which is recycled from the electrowinning cells that normally has less than about 20 ppm gold. In a Zadra process, eluant containing high concentrations of gold significantly slows down the elution process because equilibrium conditions prevent the efficient elution of gold from the carbon; that is, the equilibrium that exists between gold dissolved in solution and adsorbed on the carbon.

Recycling Circuit for Barren Electrowinning Solution

An additional embodiment is shown in FIG. 3, where the recycled eluant 60 is the spent electrolyte or electrowinning solution 70 from the electrowinning cells.

FIG. 3 shows the major operations of this embodiment. Figure 3 is the same as FIG. 1, except that in FIG. 3:

1. At least about 50% by volume of the input to the recycled eluant tank 50 comes from the electrowinning cells, which is outside of the elution process, rather than or in addition to recycled eluant that was not electrowon;
2. At least about 30 % by volume of the fresh eluant 30 is introduced into the carbon elution column 18 ahead of the recycled eluant 30, rather than in the reverse sequence; and
3. All gold-loaded eluants 40 from the carbon elution column 18 are combined in the pregnant solution tank 46, rather than being split into two streams.

This embodiment relates to the sequence of introducing the eluants (fresh 30 and recycled 60) into the carbon elution column 18. The fresh eluant 30 is introduced first, then the recycled eluant 60 from the electrowinning cells. The gold-loaded eluants 42 are combined in the pregnant solution tank 46.

Operation of the Recycle Circuit

Referring to Fig. 3 in recovering gold from gold-loaded eluant 40 by electrowinning, conductivity reagents, such as sodium hydroxide and sodium cyanide, are added to improve the conductivity of the electrowinning solution. The concentration of the conductivity reagent(s) typically ranges from about 0.5 to about 1% . Recycling the barren electrowinning solution back to the elution circuit, thus using a recycled eluant 60, will reduce the cost of using these reagents.

In an elution/electrowinning circuit with a continuously recirculating of electrowinning solution, a fraction of the total solution is typically removed as a "bleed" solution to prevent the build up of deleterious amounts of salts in the system. This bleed solution is typically about 10-30% of the total volume.

To maintain a constant volume of eluant solution, fresh water and reagents are mixed with the barren electrowinning solution or recycled eluant 60 that will be used in the next elution cycle.

The fresh eluant 30 preferably contains about 1% sugar. More sugar may be added to the recycled eluant to increase its sugar content to 2%. The recycling process starts after the carbon in the carbon elution column 18 has been deactivated by the carbon deactivator solution 22 and the solution 22 has been drained out of the carbon elution column 18. The recycling process involves introducing fresh eluant 30 into the column 18 before the recycled eluant 60. All gold loaded eluants 40 go to the pregnant solution tank 46 that feeds the electrowinning cells. Unlike the prior embodiment, this additional embodiment brings the fresh eluant 30 in contact with the fresh carbon typically only once until it passes through the electrowinning cells again.

This additional embodiment takes advantage of the high rate of gold elution using an eluant containing sugar to improve the overall efficiency. Savings in reagents are directly proportional to the fraction of recycled eluant being used.

Regeneration of the Sorbent

5 After displacement of the metal/metal complexes by the blinding agent, the process further includes a method for regenerating the sorbent by removal of the blinding agent. In the method, the stripped sorbent in the carbon elution column or vessel is contacted with an acid wash solution. The acid wash solution can include any suitable mineral acid, such as nitric acid, hydrochloric acid, sulfuric acid, and/or an organic acid such as glycolic acid as
10 described in U.S. Application Serial No. 09/454,584, filed December 6, 1999, and entitled "Method for the Regeneration of Activated Carbon" which is incorporated herein by reference in its entirety, and preferably has a pH ranging from about pH 0.1 to about pH 5 and more preferably from about pH 0.5 to about pH 2. The concentration of the acid in the acid wash solution preferably ranges from about 0.5 to about 25 vol.% and more preferably
15 from about 3 to about 5 vol%.

While not wishing to be bound by any theory, it is believed that the blinding agent, in the presence of the acidic pH, is at most only weakly attracted to the sorbent, thereby causing a large fraction (typically at least about 90%) of the blinding agent into the solution from the sorbent surface. In other words, in the presence of a basic pH, the equilibrium
20 between the blinding agent in the solution and the blinding agent on the surface of the sorbent strongly favors the attachment of the blinding agent to the sorbent surface. In contrast in the presence of an acidic pH, the equilibrium between the dissolved blinding

agent and the blinding agent on the surface of the sorbent strongly favors the dissolution of the blinding agent.

The temperature of the acid wash typically ranges from about 80 to about 95°C.

After the solvent has been contacted with the acid wash for a time typically ranging
5 from about 1 to about 2 hours, the regenerated sorbent can be rinsed with water to remove residual acid solution.

The sorbent can then be reused in a variety of known processes to remove dissolved metal/metal complexes from pregnant lixiviant solutions, industrial effluents, waste waters, etc., to form metal/metal complex loaded sorbent for use as the feed material in any of the
10 elution processes described above.

Other Process Embodiments

A process according to another embodiment is shown in Fig. 4. The process assumes that the metal, which in the embodiment is gold, has been removed from a cyanide lixiviant onto activated carbon by known techniques. The gold/silver-loaded carbon (loaded carbon)
15 is transferred to the Carbon Elution column or Vessel (CEV) 100 and preheated to operating temperatures preferably from about 95-98°C by recirculating a hot pretreatment cyanide solution 102 introduced at the bottom of the CEV 100 in a fluidized bed configuration. After the pretreatment period, the cyanide solution 102 in the CEV is returned to the Bleed Tank (BT) 104 by displacing the cyanide solution with a heated barren solution 108 from the
20 Barren Solution Tank (BST) 112. The carbon is further rinsed with barren solution 108 and which into the BT 104.

The barren solution 108 is heated to a temperature of about 95°C to about 98°C before entering the CEV 100. The gold/silver-loaded solution (pregnant solution) 116 flows out the top of the tank 100 and into the Bleed Tank (BT) 104 or the Pregnant Solution Tank (PST) 120. The first 2 to 4 bed volumes (BV) of pregnant solution (which typically
5 represents from about 20 to about 35 vol.% of the total or combined pregnant solution volume) go to the BT 104 since it contains the highest concentration of impurities. Typical impurities include one or more of sodium cyanide, sodium ions, and base metal cyano complexes. The pregnant solution 116 in the BT typically has about 40 wt% or more of impurities (more typically about 75 wt% or more) while the pregnant solution in the PST
10 120 typically has no more than about 30 wt% impurities (and more typically no more than about 20 wt%). The rest of the pregnant solution goes to the PST 120. Gold/silver in the BT and the PST solutions are electrowon separately (e.g., with separate circuits) with the BT solution 124 going to electrowinning circuit 128 and the PST solution 132 going to electrowinning circuit 136. The BT barren solution goes to the leach circuit (not shown),
15 e.g., Carbon-in Leach (CIL) circuit, and the PST barren solution 144 recycled back to the Barren Solution Tank (BST) 112. The process parameters in the CEV 100 are set forth above and below. The typical residence time of the eluant in the CEV 100 ranges from 30 minutes to 45 minutes.

The operation of the invention will be described with reference to Fig 4. As
20 indicated in Fig. 4, the gold-loaded carbon (loaded carbon) is loaded into the Carbon Elution Vessel (CEV) 100. The temperature of the carbon is raised to about 95-98°C by recirculating a hot cyanide solution 102 between the Bleed Tank (BT) 104 and the CEV 100. This step takes about one to four hours depending on the concentration of cyanide used. The

concentration of cyanide in the pretreatment solution, which typically ranges from about 3 to about 10 wt%, and the duration of the pretreatment period, which typically range from about 1 to about 4 hours play a significant role in the final eluted carbon assay as shown in Fig. 6.

5 The pregnant solution 116 and cyanide solution are combined or mixed in the same BT tank or vessel as one has a low cyanide concentration and high gold concentration and the other has a high cyanide concentration and low gold concentration. The combined or mixed solution is subjected to electrowinning for gold recovery. As will be appreciated, the presence of the cyanide in the combined solution assists in gold recovery.

10 The cyanide is rinsed off the carbon preferably with about 2 to 4 bed volume (BV) of barren solution 108 with the rinse solution reporting with the used sodium cyanide in the BT 104. The BT solution 124 is electrowon to recover the gold, preferably using a separate electrowinning cells to that of the pregnant solution 132 from the Pregnant Solution Tank (PST) 120.

15 Hot barren solution from the BST 112 is passed through the carbon elution vessel 100 to elute the precious metals from the carbon at about two bed volumes (BV) per hour. The barren solution when first prepared contains about 0.5-1 wt.% of sucrose and about 0.1-0.2 wt.% ammonia in commonly available water, such as mill process water. After the initial elution, the barren solution comes from the electrowinning cells after the precious
20 metals had been electrowon from the pregnant solution 132 of the PST 120.

Fresh eluant 150 (e.g., water containing about 1 wt.% sucrose) follows the barren solution eluant. The amount of fresh eluant 150 used should be enough to maintain the volume of barren solution in the BST 112 before each elution cycle (e.g., about 4BV if the bleed used is about 4BV per cycle).

5 The concentration of sucrose and ammonia are maintained by addition of sucrose, and ammonia to the barren solution 108. Ammonia is preferably added in the electrowinning cells to maintain an electrowinning cell pH of at least 10. Sugar is added to the fresh eluant (process water)

10 The concentration of impurities, e.g., nickel, copper, sodium, etc., in the barren solution is controlled by the amount of the pregnant solution 116 reporting as bleed solution on each elution cycle to the BT 104. Two to four bed volumes of bleed solution is required and is always the first couple of bed volumes of barren solution after the cyanide pretreatment. The bleed solution 124 in the BT 104 is electrowon in cells 128 with the barren bleed solution 144 discharged into the leach circuit where the cyanide carried by the
15 solution can be used and residual gold/silver can be recovered.

The pregnant solution 132 in the PST 120 is electrowon in cells 136 with the barren solution 144 recycling back to the Barren Solution Tank (BST) 112 for reuse.

20 An additional embodiment is shown in Fig. 5, where the pregnant solution is divided into two parts: pregnant solution (PS1) 200 and pregnant solution (PS2) 204. Assuming that the total volume of eluant (not including the bleed) is about 10BV, the first 5BV goes to the pregnant solution tank (PST1) 208 and the next 5BV goes to the pregnant solution tank (PST2) 212. PS1 200 is electrowon in electrowinning circuit 136 while PS2 204 is not electrowon but used as the initial eluant after the cyanide pretreatment.

There are two recycled eluants; PS2 216 and barren solution 108 from the BST112. PS2 solution 216 did not pass through the electrowinning cell in contrast to the barren solution, which is PS1 220 after it passed through the electrowinning cells 136. Typically the concentration of gold in the barren solution 108 and PS2 216 are, less than about 2ppm and greater than about 15ppm respectively.

PS2 216 is used as the initial eluant after the cyanide pretreatment, followed by the barren solution 108 thereby decreasing reagent consumption and energy cost, and reducing the volume of pregnant solution that goes to the electrowinning cells by approximately one-half.

10

EXPERIMENTAL

Standard conditions used in the examples below are as follows:

1. The samples were derived Carbon-in-Leach (CIL) carbons.
2. The carbons were acid-washed with nitric acid solution at pH 1 and neutralized to about pH 10, unless otherwise noted.
3. Elution Temperature: 95-98°C.
4. Carbons were treated for one hour with hot recirculating 5% NaCN solution to reduce its activity.
5. Eluant flow: 1.5 bed volumes per hour except in Example 1 (used 2 BV/h).
6. Duration of elution: 5 hours.

20

The sugar/calcium eluant in these examples consists of distilled water or tap water with lime.

25

Example 1

FIG. 2-A and Table 1 show how the calcium ions affect the elution recovery curve for distilled water with and without sugar.

5

Table 1

	Eluant	Carbon Assay (ppm) Head Tail		% Gold Recovered AFTER (HOURS)				
				1	2	3	4	5
W	D.W.+1% Sugar	5773	118	65.7	88.0	94.3	97.0	98.0
V	D.W.+1% Sugar+60 ppm Ca	6850	175	50.7	82.2	91.7	95.8	97.4
T	Distilled Water (D.W.)	6444	228	54.8	81.8	91.7	95.1	96.5
S	Distilled Water+60 ppm Ca	6863	370	47.5	76.2	86.9	91.9	94.6

The presence of calcium ions in the eluant suppresses the elution of gold cyanide from the carbon. It is believed that the calcium forms a calcium gold cyanide complex, which is strongly held by the carbon. Table 1 shows that, by adding sugar to the eluant, the formation of calcium gold cyanide complex is reduced, if not eliminated, thereby improving the elution of gold from the carbon.

Example 2

FIG 2-B and Table 2 show an elution method similar to Example 1 at 1.5BV per hour and using tap water.

Table 2

	Eluant	Carbon Assay (ppm) Head Tail		% Gold Recovered AFTER (HOURS)				
				1	2	3	4	5
P	Tap water (10ppmCa)+1% Sugar	6525	135	42.1	83.5	93.8	96.6	97.9
O	Distilled Water+1% Sugar+Ca (60 ppm)	6109	117	39.4	81.9	93.5	96.9	98.1
M	Distilled Water+1% Sugar	6054	112	41.7	81.4	93.8	97.2	98.1
L	Distilled Water	6361	117	37.4	77.5	92.8	96.9	98.2
Q	Tap Water (10ppm Ca)	6259	149	39.1	70.6	87.3	94.8	97.6

Table 2 shows that the elution efficiency can be reduced by 10 ppm calcium ions in the eluant. Sugar at 1 percent by weight can improve gold elution recovery, even in the presence of higher concentrations of calcium ions.

Example 3

FIG 2-C and Table 2 show the elution profile of the elution process in relation to the Zadra and Anglo processes. The elution process of the present invention has a higher rate of elution than the Anglo or Zadra processes, particularly at the early stages of the elution cycle.

Table 3

	Eluant	Carbon Assay (ppm) Head Tail		% Gold Recovered AFTER (HOURS)				
				1	2	3	4	5
F	1% Sugar + 70PPM Ca	6692	165	43.6	82.3	93.4	96.3	97.5
G	Anglo - Distilled water	6937	143	30.4	76.1	91.3	95.9	97.9
I	Zadra - Recycled Barren Solution, 1%NaOH+0.1%NaCN, 16ppm AU	6540	2540	20.5	35.9	46.6	54.7	61.2

Example 4

Fig. 2-D and Table 4 show one way of improving the performance of the Zadra process. The eluant in the Zadra process is recycled and has a "bleed" to reduce the build-up of deleterious concentration of salts in the eluant. Normally, this bleed represents about 10-30% of the total volume of eluant. Fresh solution is added to the recirculating eluant to replace the bleed solution. Instead of adding the fresh eluant into the recirculating eluant, the fresh eluant of sugared water is used as the initial eluant solution. The higher the percentage of fresh eluant in the elution, the greater the efficiency of elution. Gold elution is favored by low ionic strength eluant, *i.e.*, fresh sugared water eluant. As will be appreciated, the recycled electrowinning barren solution has a high ionic strength due to the addition of caustic to improve the electrowinning. Therefore, it is advantageous to the elution process if fresh eluant is used first and later followed by the recycled barren electrowinning barren solution.

In one process configuration, the fresh eluant preferably contains no more than about 35% by volume, more preferably no more than about 25% by volume, and even more preferably is substantially free of recycled eluant. Preferably, the fresh eluant contains no

more than about 1,000 ppm sodium ions and more preferably no more than about 500 ppm sodium ions. Typically, the recycled eluant contains no more than about 45% by volume fresh eluant and more typically no more than about 25% by volume fresh eluant. Typically, the recycled eluant contains 5,000 ppm or more sodium ions and more typically about 7,500 ppm or more sodium ions. During the elution process as a whole the total volume of eluant used is typically from about 25 to about 50% by volume fresh eluant.

Table 4

	Eluant	CarbonAssay (ppm)Head Tail		% Gold RecoveredAFTER (HOURS)				
				1	2	3	4	5
F	7.5 BV Sugar/calcium solution	6692	165	43.6	82.3	93.4	96.3	97.5
J	2.25BV Sugar/Ca, then 5.25BV Zadra (5% sugar)	6736	779	40.4	75.8	81.4	85.7	88.4
D	1.5BV Sugar/Ca, then 6BV Zadra (5% sugar)	6741	1400	38.4	54.4	66.1	74.0	79.2
I	7.5BV Recycled Zadra solution	6560	2540	20.5	36.1	46.7	54.8	61.3

Example 5

FIG. 2-E and Table 5 show the elution efficiency of the sugar/calcium eluant in three successive cycles. The elution profiles show that the eluant can be recycled without negative effect.

Table 5

	Cycle No.	Eluant	Carbon Assay (ppm) Head Tail		% Gold Recovered AFTER (HOURS)				
					1	2	3	4	5
F	0	7.5 BV - 1% Sugar + 60ppm Ca in Tap Water	6692	165	43.6	82.3	93.4	96.3	97.5
F1	1	3.65 BV - recycled Eluant from Cycle 0, then 3.75 BV - Fresh Eluant	6644	149	43.0	76.6	89.2	95.3	97.8
F2	2	3.75 BV - Recycled Eluant from Cycle 1, then 3.75 BV - Fresh Eluant	6840	236	43.8	72.8	86.4	93.9	96.5
F3	3	3.75 BV - Recycled Eluant from Cycle 2, then 3.75 BV - Fresh Eluant	6783	122	41.2	75.7	89.6	96.2	98.2

Example 6

FIG. 2-F and Table 6 compares the elution efficiency of the acid washed carbon and the non-acid washed carbon.

Table 6

	Treatment	Eluant	Carbon Assay (ppm) Head Tail		% Gold Recovered AFTER (HOURS)				
					1	2	3	4	5
F	Acid-Washed	Sugar/Ca	6692	165	43.6	82.3	93.4	96.3	97.5
H	Not-Acid Washed	Sugar/Ca	6616	246	36.8	76.6	90.1	94.4	96.3
K	Not-Acid Washed	Distilled Water	6748	204	34.6	70.7	86.7	93.4	97.0

Table 6 shows that the elution of gold is improved by first acid washing the carbon before elution to remove impurities. It is believed that by removing the impurities in the carbon

pores, migration of the solution into and out of the carbon pores is facilitated, thereby improving removal of the gold complex from the carbon.

Example 7

Standard conditions used in Examples 7 and 8 below are as follows:

- (a) The samples were dried Carbon-in-Leach (CIL) carbons.
- (b) Elution Temperature: 95-98°C.
- (c) Carbons were treated for one hour with hot recirculating 5% NaCN solution.

A loaded carbon containing about 1500 g/t gold, 285 g/t silver, 146 g/t copper, and 2058 g/t nickel was subjected to the elution process of Fig. 4 and yielded the following results.

Table 7

From Mine A	Gold, g/t	Silver, g/t	Copper, g/t	Nickel, g/t
Loaded Carbon	1500	284	146	2058
Eluted Carbon	61	66	37	48

The carbon was not acid washed before elution. Due to the presence of sugar and ammonia in the eluant, ammonia being a mass transfer agent, the elution of gold, silver, copper and nickel was maintained at acceptable levels.

Example 8

A loaded carbon containing 14700/t gold and 156g/t silver from mine "B" was subjected to the elution process of Fig. 5 and yielded the following results:

From Mine B	Gold, g/t	Silver, g/t	Copper, g/t	Nickel, g/t
Loaded Carbon	14700	156	25	613
Eluted Carbon	133	12	13	30

Example 8 shows that results can be obtained that are similar to those of the prior Example using the flowsheet of Figure 5.

Example 9

A method for comparing carbon activity was used to compare the following carbon regeneration treatments.

- Spent carbon, with no regeneration treatment;
- Spent carbon, acid washed at 95°C with nitric acid (HNO₃);
- Spent carbon, acid washed at 95°C with hydrochloric acid (HCl);
- Spent carbon, acid washed at 95°C with glycolic acid (GA);
- Spent carbon, acid washed at 95°C with sulfuric acid (H₂SO₄); and
- Spent carbon, with thermal regeneration.

The methodology involves presoaking one gram of carbon sample in "tailings" slurry for one hour before adding the carbon to one liter of standard gold cyanide solution containing about 10 ppm gold and buffered to pH 10. The purpose of presoaking the carbon in the tailings slurry was to neutralize the "pH effect" of the acid treatment on carbon activity. The carbon samples were screened to minus 8-mesh and plus 10-mesh. At 15 minutes time intervals, small aliquots of test solution were removed to determine the remaining gold concentration.

Figure 7 shows the carbon activity of carbon that has not been regenerated by acid washing to provide a baseline or that has been regenerated by acid washing using various acids, namely nitric acid, hydrochloric acid, sulfuric acid, or glycolic acid or, though not acid washed, was thermally reactivated or regenerated using conventional techniques.

The data in Figure 7 shows no significant improvement in carbon activity was attributed to the use of nitric and hydrochloric acid wash. Conventional acid washing allows for the removal of minerals containing calcium, magnesium and aluminum. The removal of these minerals proves helpful in improving thermal regeneration of the carbon.

On the other hand, the data shows that washing with sulfuric or glycolic acid solution significantly improved carbon activity. It is possible that thermal regeneration can be significantly reduced or eliminated in gold-adsorption processes such as carbon-in-leach or CIL or carbon-in-pulp or CIP.

Maximum carbon regeneration was achieved by thermal regeneration at a price of high carbon losses. It is not always necessary to have a carbon that has very high activity. The gold adsorption process will dictate the required carbon activity for optimum operation.

Conclusions, Ramifications and Scope

It is clear that blinding agents such as sucrose enhance the elution of metals/metal complexes such as gold cyanide complexes from sorbents such as activated carbon. The eluting process of the present invention extends present knowledge of elution chemistry. Furthermore, the process of the present invention has additional advantages over the prior art in that:

1. It allows the use of commonly available water and reagents;
2. It allows the recycling of metal-loaded eluant containing high concentrations of metal;
3. It provides a fast elution method at 95-98°C and faster still at higher temperatures;
4. It provides a metal-loaded eluant one-half the volume required by prior art;
5. It provides a metal-loaded eluant chemistry suitable for precipitation or electrowinning;
6. It provides a once-through or recirculation-type elution;
7. It provides a simple means of regenerating the sorbent immediately after elution using the same vessel; and
8. It provides a simple, economical, and efficient method of eluting metals/metal complexes from activated carbon and other sorbents.

The specific data in the examples described above are merely illustrative; they do not limit the scope of the invention. Various ramifications are possible within the scope of the invention. For example, operating at higher than suggested temperature will further enhance the elution of the metal/metal complexes. The metal-loaded sorbent need not be washed with acid before elution to benefit from this invention. Sugar is a carbohydrate containing carbon, hydrogen and oxygen only. Other carbohydrates include: (a) monosaccharides including sugars, such as glucose and fructose, (b) disaccharides including the sugars sucrose, maltose, and lactose, and (c) polysaccharides including cellulose, starch, and glycogen. Monosaccharides are polyhydroxy aldehydes or ketones, usually referred to as aldoses and ketoses, respectively.

Thus, the scope of the invention should be determined by the appended claims and their legal equivalents, rather than by the examples given.

What is claimed is:

1. A method for solubilizing a metal from a substrate carrying the metal, comprising contacting the substrate with a stripping solution containing an at least substantially nonpolar molecule, wherein the at least substantially nonpolar molecule displaces the metal from the substrate.
2. The method of Claim 1, wherein the substrate is a sorbent that is at least one of carbon, resin, and polymers.
3. The method of Claim 2, wherein the metal is adsorbed onto the substrate.
4. The method of Claim 1, wherein the metal is a member of any one of Groups VIIIA, IB, or IIB of the Periodic Table of the Elements.
5. The method of Claim 4, wherein the metal is selected from the group consisting essentially of gold, silver, platinum, copper, nickel, cobalt, mercury, and mixtures thereof.
6. The method of Claim 1, wherein the stripping solution includes a solvent for the at least substantially nonpolar molecule, the solvent being at least substantially polar.
7. The method of Claim 6, wherein the solvent is selected from the group consisting of water, alcohols, and mixtures thereof.

8. The method of Claim 1, wherein the at least substantially nonpolar molecule is selected from the group consisting essentially of a carbohydrate, a hydrocarbon, ammonia, molecular nitrogen, and mixtures thereof.

9. The method of Claim 6, wherein the stripping solution includes a mass transfer agent different from the solvent and the at least substantially nonpolar molecule and the mass transfer agent is an at least substantially nonpolar molecule.

10. The method of Claim 9, wherein the mass transfer agent is a gas molecule and the at least substantially nonpolar gas molecule is at least one of ammonia and nitrogen.

11. The method of Claim 10, further comprising the step of sparging the mass transfer agent through the stripping solution before the contacting step.

12. The method of Claim 1, wherein the metal is adsorbed on the substrate in the form of metal cyanide complex.

13. The method of Claim 8, wherein the at least substantially nonpolar molecule is a carbohydrate selected from the group consisting of monosaccharides, disaccharides, polysaccharides and mixtures thereof.

14. The method of Claim 1, wherein the at least substantially nonpolar molecule is a hydrocarbon that is selected from the group consisting of paraffins, alkenes, olefins, alkadienes, acetylenes, acyclic terpenes and mixtures thereof.

15. A metal product recovered by the method of Claim 1.

16. A stripping solution for removing a metal carried by a sorbent, comprising:
an at least substantially nonpolar blinding agent for displacing the metal from the
sorbent and

an at least substantially polar solvent for the blinding agent.

17. The stripping solution of Claim 16, wherein the metal is adsorbed onto the
sorbent.

18. The stripping solution of Claim 16, wherein the metal is a member of any of
Groups VIIIA, IB or IIB of the Periodic Table of the Elements.

19. The stripping solution of Claim 18, wherein the metal is selected from the
group consisting essentially of gold, silver, platinum, copper, nickel, cobalt, mercury, and
mixtures thereof.

20. The stripping solution of Claim 16, wherein the solvent is selected from the
group consisting of water, alcohols, and mixtures thereof.

21. The stripping solution of Claim 16, wherein the at least substantially nonpolar
blinding agent is selected from the group consisting essentially of a carbohydrate, a
hydrocarbon, ammonia, molecular nitrogen, and mixtures thereof.

22. The stripping solution of Claim 16, further comprising a mass transfer agent different from the solvent and the at least substantially nonpolar blinding agent and the mass transfer agent is an at least substantially nonpolar molecule.

23. The stripping solution of Claim 22, wherein the at least substantially nonpolar is a gas molecule that is at least one of ammonia and nitrogen.

24. The stripping solution of Claim 16, wherein the metal is adsorbed on the sorbent in the form of metal cyanide complex.

25. The stripping solution of Claim 16, wherein the blinding agent includes at least one saccharose units.

26. The stripping solution of Claim 16, wherein the concentration of the blinding agent ranges from about 0.1 to about 5wt.%.

27. A pregnant solution generated by displacement of a metal complex adsorbed onto a sorbent, comprising:
- an at least substantially nonpolar blinding agent for displacing the metal from the sorbent;
 - 5 an at least substantially polar solvent for the blinding agent; and
 - a dissolved metal.
28. The pregnant solution of Claim 27, wherein the metal is adsorbed onto the sorbent.
29. The pregnant solution of Claim 27, wherein the metal is a member of any of Groups VIIIA, IB or IIB of the Periodic Table of the Elements.
30. The pregnant solution of Claim 29, wherein the metal is selected from the group consisting essentially of gold, silver, platinum, copper, nickel, cobalt, mercury, and mixtures thereof.
31. The pregnant solution of Claim 27, wherein the solvent is selected from the group consisting of water, alcohols, and mixtures thereof.
32. The pregnant solution of Claim 27, wherein the at least substantially nonpolar blinding agent is selected from the group consisting essentially of a carbohydrate, a hydrocarbon, ammonia, molecular nitrogen, and mixtures thereof.

33. The pregnant solution of Claim 27, further comprising a mass transfer agent different from the solvent and the at least substantially nonpolar molecule and the mass transfer agent is an at least substantially nonpolar molecule.

34. The pregnant solution of Claim 33, wherein the mass transfer agent is a gas molecule and the at least substantially nonpolar gas molecule is at least one of ammonia and nitrogen.

35. The pregnant solution of Claim 27, wherein the metal is adsorbed on the sorbent in the form of metal cyanide complex.

36. The pregnant solution of Claim 27, wherein the pregnant solution has a pH ranging from about pH 9 to about pH 13.

37. The pregnant solution of Claim 27, wherein the blinding agent has a concentration of from about 0.2 to about 2 wt.% and the metal of from about 1 ppm to about 5,000 ppm.

38. Residue from a metal collection process, the residue comprising:
a sorbent carrying a blinding agent that is at least substantially nonpolar and a metal complex.
39. The residue of Claim 38, wherein the metal complex is a metal cyanide complex.
40. The residue of Claim 38, wherein the metal in the metal complex is a member of any of Groups VIIIA, IB or IIB of the Periodic Table of the Elements.
41. The residue of Claim 40, wherein the metal is selected from the group consisting essentially of gold, silver, platinum, copper, nickel, cobalt, mercury, and mixtures thereof
42. The residue of Claim 38, further comprising a mass transfer agent different from the at least substantially nonpolar blinding agent, the mass transfer agent being carried by the sorbent, and wherein the mass transfer agent is an at least substantially nonpolar molecule.
43. The residue of Claim 38, wherein the blinding agent is at least one of a carbohydrate, a hydrocarbon, ammonia, molecular nitrogen, and mixtures thereof.

44. The residue of Claim 38, wherein the sorbent preferentially adsorbs nonpolar molecules over polar molecules.

45. The residue of Claim 44, wherein the sorbent is at least one of activated carbon, a resin, and polymers.

46. A method for regenerating a sorbent, the sorbent carrying an at least substantially nonpolar blinding agent, the method comprising:

contacting the sorbent with a wash solution having an acidic pH to remove at least most of the at least substantially nonpolar blinding agent and form a regenerated sorbent.

47. The method of Claim 46, wherein the blinding agent is at least one of a carbohydrate, a hydrocarbon, ammonia, molecular nitrogen, and mixtures thereof.

48. The method of Claim 46, wherein the sorbent is at least one of activated carbon, a resin, and polymers.

49. A sorbent regenerated by the method of Claim 46.

50. The method of Claim 46, wherein the acid concentration ranges from about 0.5 to about 5 vol.%.

51. A method for recovering a desired metal from a sorbent, comprising:
leaching a metal from a metal-containing material using a lixiviant to form a
pregnant leach solution in which at least a portion of the metal is dissolved;
contacting the pregnant leach solution with a sorbent to form a metal-loaded sorbent
5 containing at least a portion of the metal in the pregnant leach solution;
contacting the metal-loaded sorbent with an eluant to form a loaded eluant containing
at least a portion of the metal on the metal-loaded sorbent and a barren sorbent;
recovering the metal from the metal-loaded eluant; and
regenerating the barren sorbent by contacting the barren sorbent with an acid wash
10 solution containing sulfuric acid.

52. The method of Claim 51, wherein the barren sorbent includes an at least
substantially nonpolar blinding agent that is at least one of a carbohydrate, a hydrocarbon,
ammonia, molecular nitrogen, and mixtures thereof.

53. The method of Claim 51, wherein the sorbent is at least one of activated
carbon, a resin, and polymers.

54. A sorbent regenerated by the method of Claim 51.

55. The method of Claim 51, wherein the sulfuric acid concentration in the acid wash solution ranges from about 0.5 to about 5 vol.%.

56. A method for eluting a metal from a substrate carrying the metal and one or more impurities, comprising:

first contacting the substrate with a stripping solution to form a first loaded eluant containing a portion of the metal and some of the one or more impurities on the substrate;

5 collecting the first loaded eluant in a first vessel;

second contacting the substrate with the stripping solution to form a second loaded eluant containing a portion of the metal and some of the one or more impurities on the substrate, wherein a first concentration of the one or more impurities in the first loaded eluant is more than a second concentration of the one or more impurities in the second

10 eluant; and

collecting the second loaded eluant in a second vessel that is different from the first vessel.

57. The method of Claim 56, wherein the one or more impurities include one or more of sodium cyanide, sodium ions, and base metal cyano-complexes.

58. The method of Claim 56, wherein the first concentration is about 40 wt% or more and the second concentration is no more than about 30 wt%.

59. The method of Claim 56, further comprising recovering the metal in each of the first and second loaded eluants in separate electrowinning circuits.

60. The method of Claim 56, further comprising separating the second loaded eluant into first and second portions and wherein the first portion is subjected to electrowinning and the second portion is free of electrowinning and is reused in at least one of the first and second contacting steps.

61. The method of Claim 56, wherein the substrate is a sorbent that is at least one of carbon, resin, and polymers and wherein the stripping solution contains an at least substantially nonpolar molecule, wherein the at least substantially nonpolar molecule displaces the metal from the substrate.

62. The method of Claim 61, wherein the metal is adsorbed onto the substrate.

63. The method of Claim 56, wherein the metal is a member of any one of Groups VIIIA, IB, or IIB of the Periodic Table of the Elements.

64. The method of Claim 63, wherein the metal is selected from the group consisting essentially of gold, silver, platinum, copper, nickel, cobalt, mercury, and mixtures thereof.

65. The method of Claim 61, wherein the stripping solution includes a solvent for the at least substantially nonpolar molecule, the solvent being at least substantially polar.

66. The method of Claim 65, wherein the solvent is selected from the group consisting of water, alcohols, and mixtures thereof.

67. The method of Claim 61, wherein the at least substantially nonpolar molecule is selected from the group consisting essentially of a carbohydrate, a hydrocarbon, ammonia, molecular nitrogen, and mixtures thereof.

68. The method of Claim 61, wherein the stripping solution includes a mass transfer agent different from the solvent and the at least substantially nonpolar molecule and the mass transfer agent is an at least substantially nonpolar molecule.

69. The method of Claim 68, wherein the mass transfer agent is a gas molecule and the at least substantially nonpolar gas molecule is at least one of ammonia and nitrogen.

70. The method of Claim 69, further comprising the step of sparging the mass transfer agent through the stripping solution before the contacting step.

71. The method of Claim 56, wherein the metal is adsorbed on the substrate in the form of metal cyanide complex.

72. The method of Claim 61, wherein the at least substantially nonpolar molecule is a carbohydrate selected from the group consisting of monosaccharides, disaccharides, polysaccharides and mixtures thereof.

73. The method of Claim 61, wherein the at least substantially nonpolar molecule is a hydrocarbon that is selected from the group consisting of paraffins, alkenes, olefins, alkadienes, acetylenes, acyclic terpenes and mixtures thereof.

74. A metal product recovered by the method of Claim 59.

Fig. 1

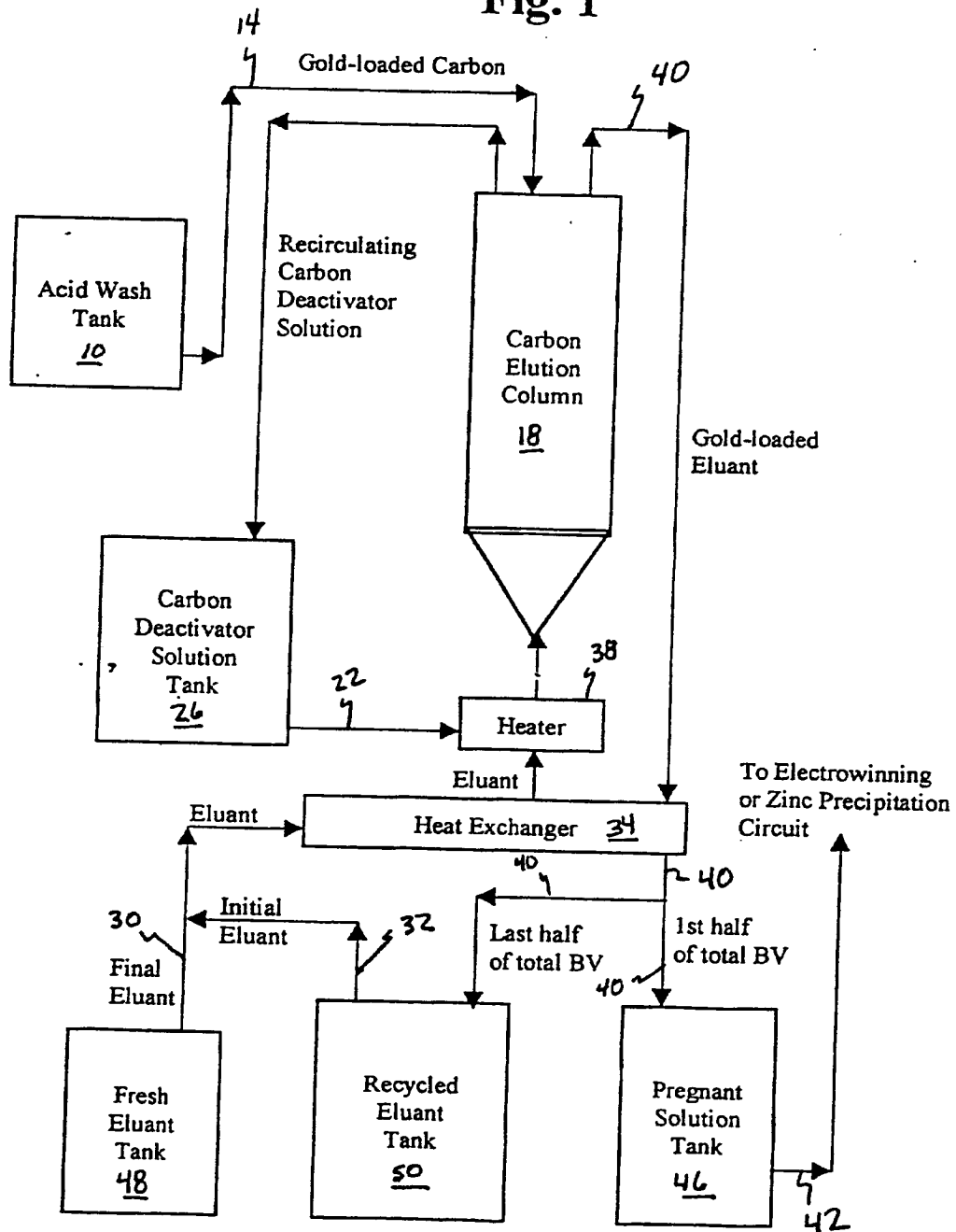


FIG. 2-A

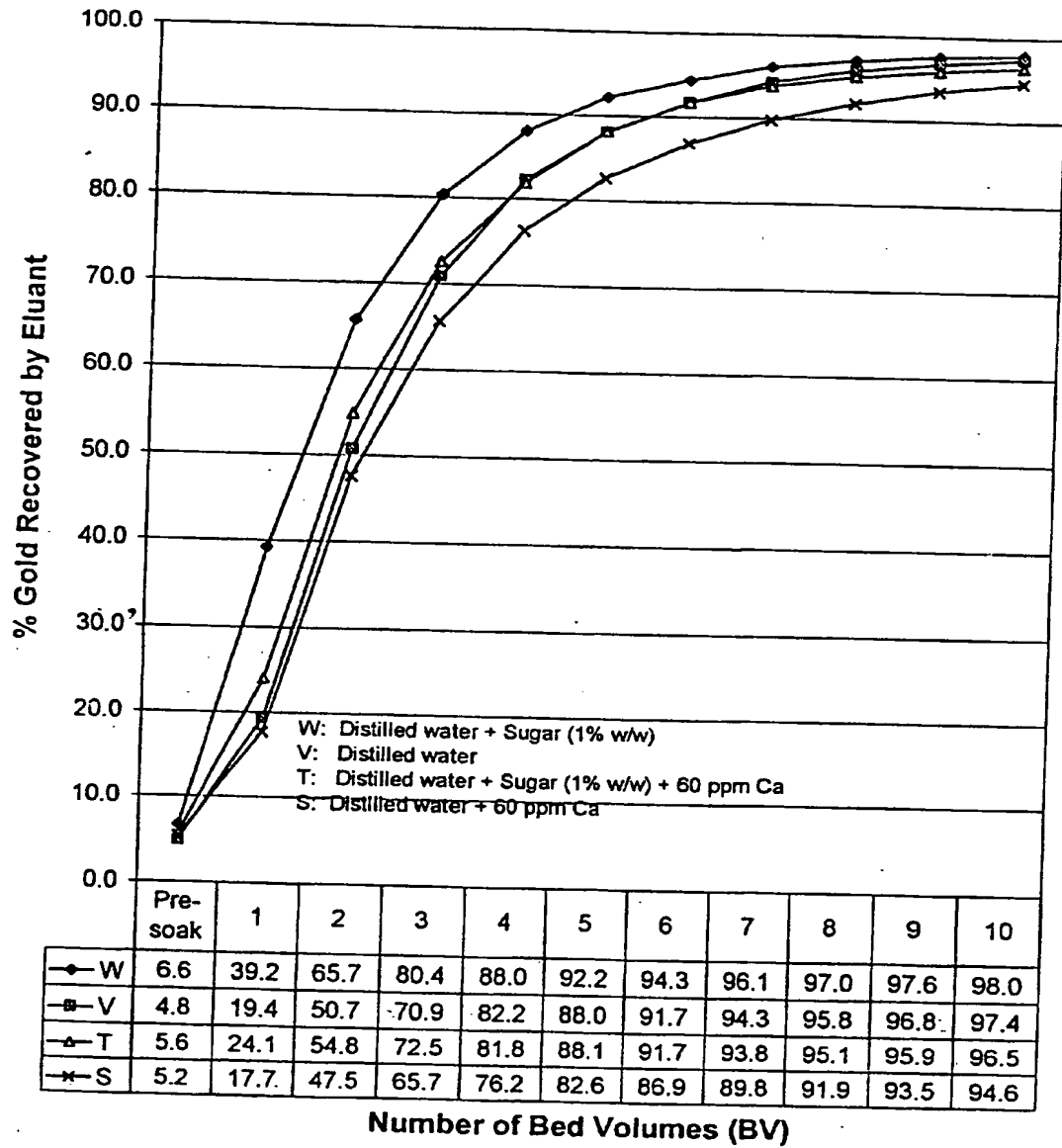
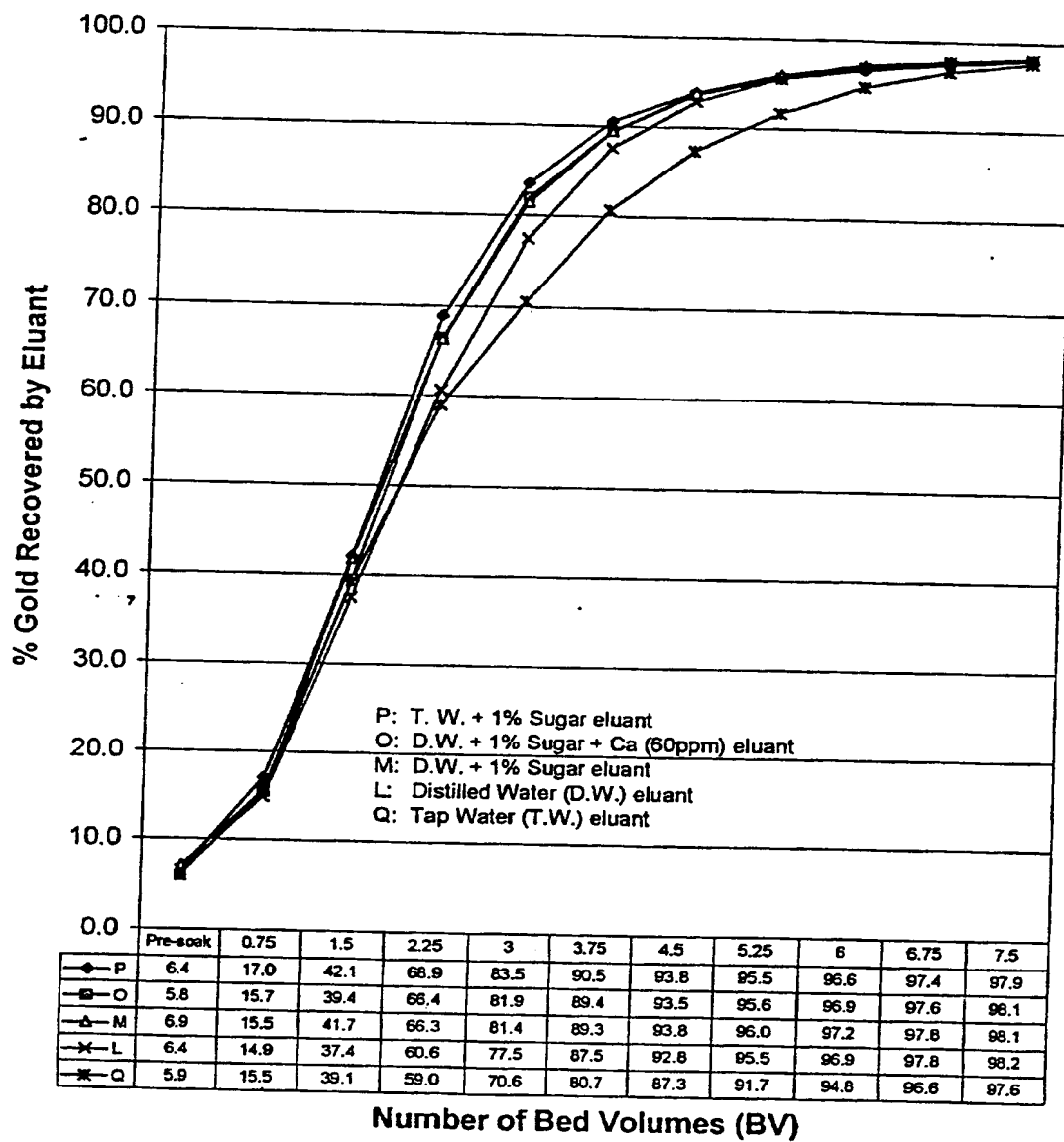


FIG. 2-B



Number of Bed Volumes (BV)

FIG. 2-C

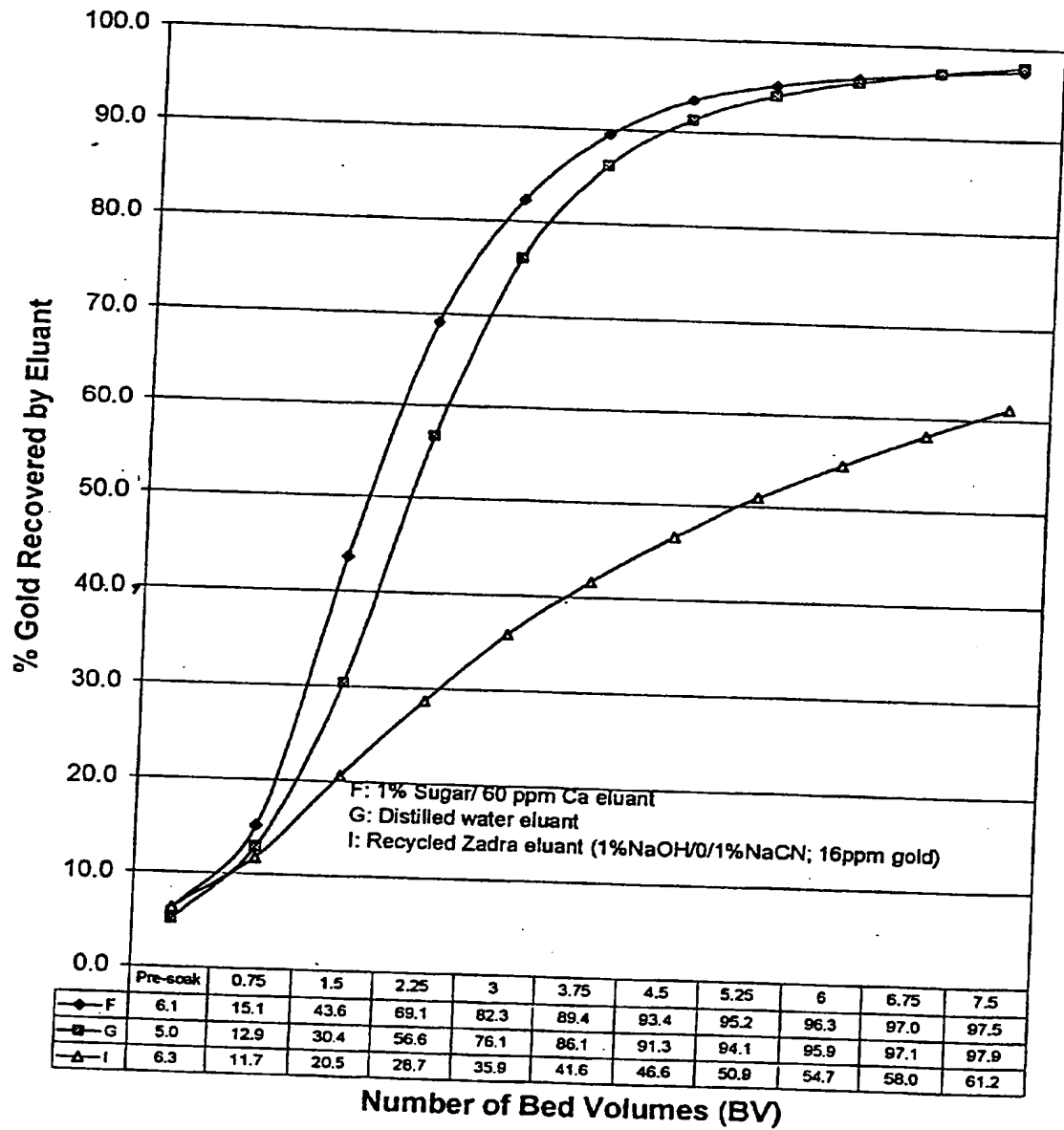


FIG. 2-D

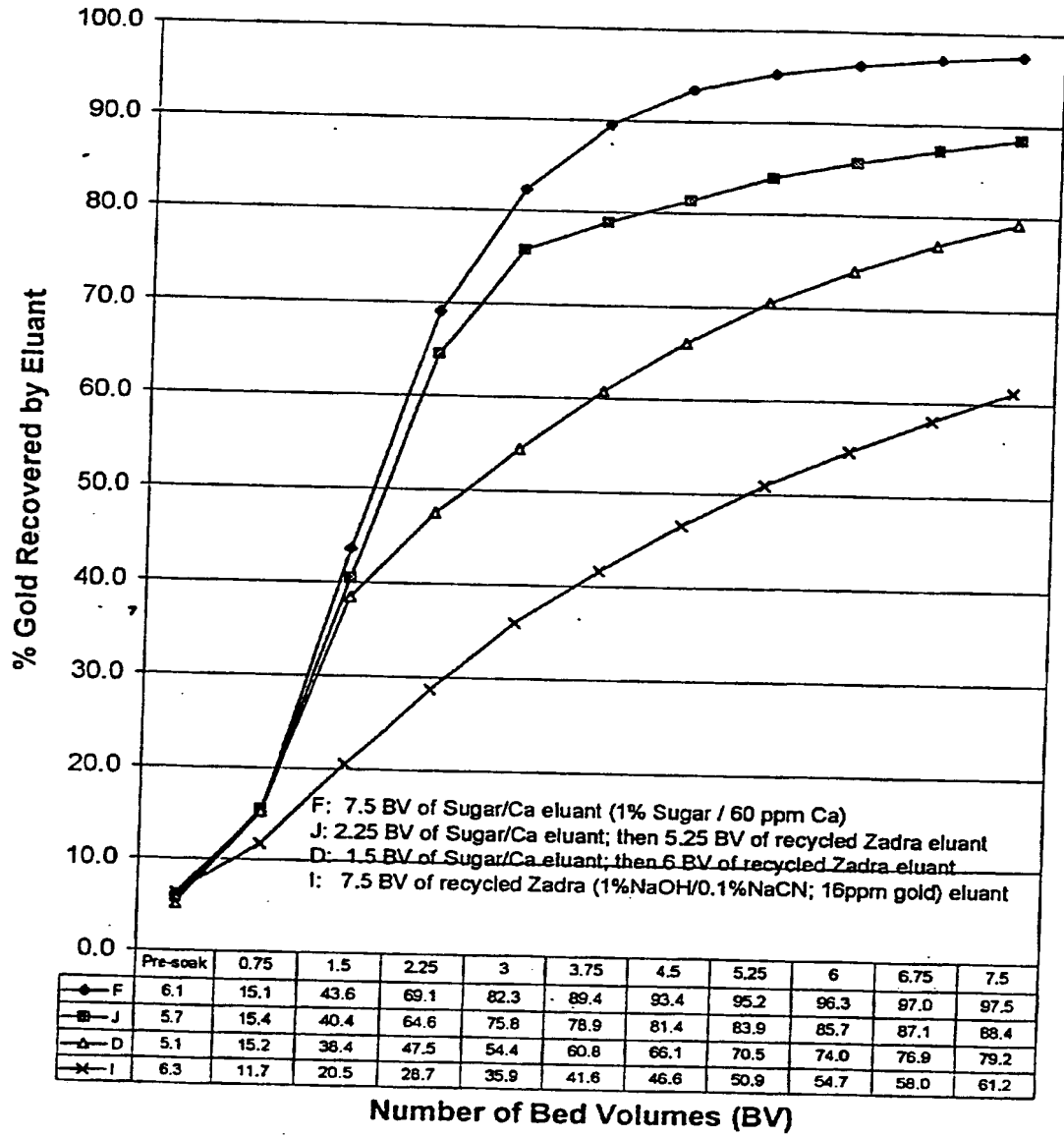


FIG.2-E

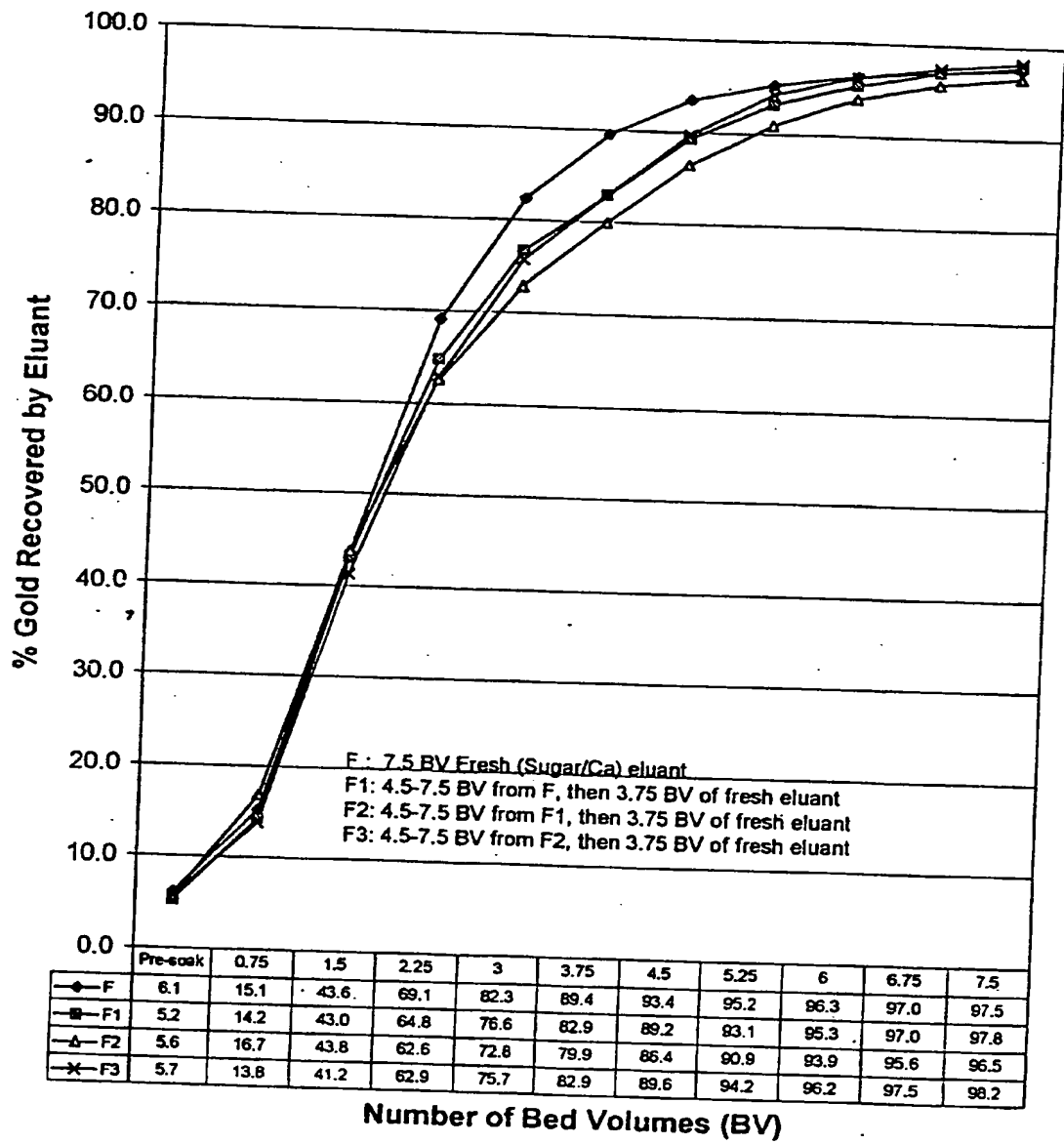


FIG. 2-F

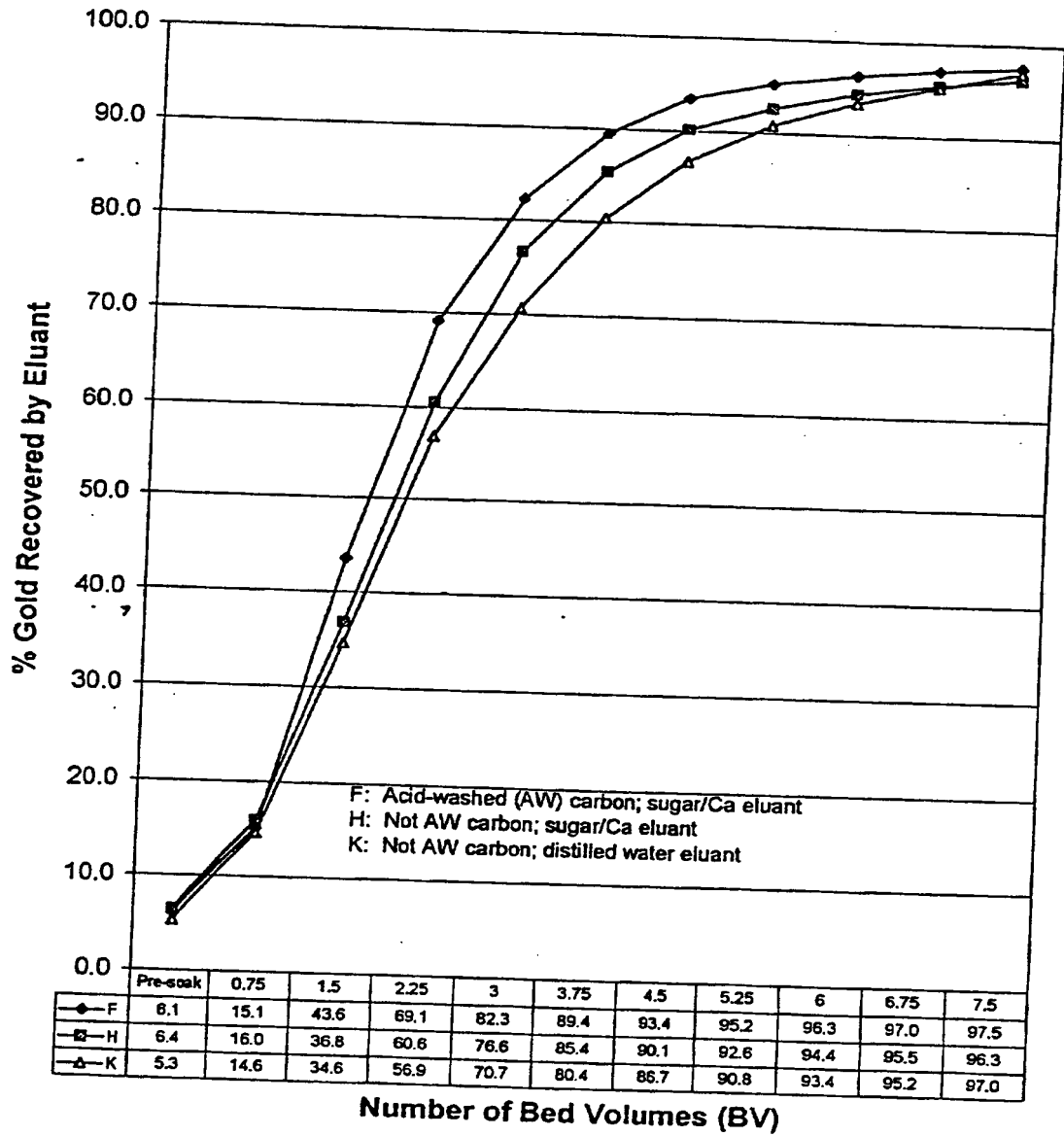


Fig. 3

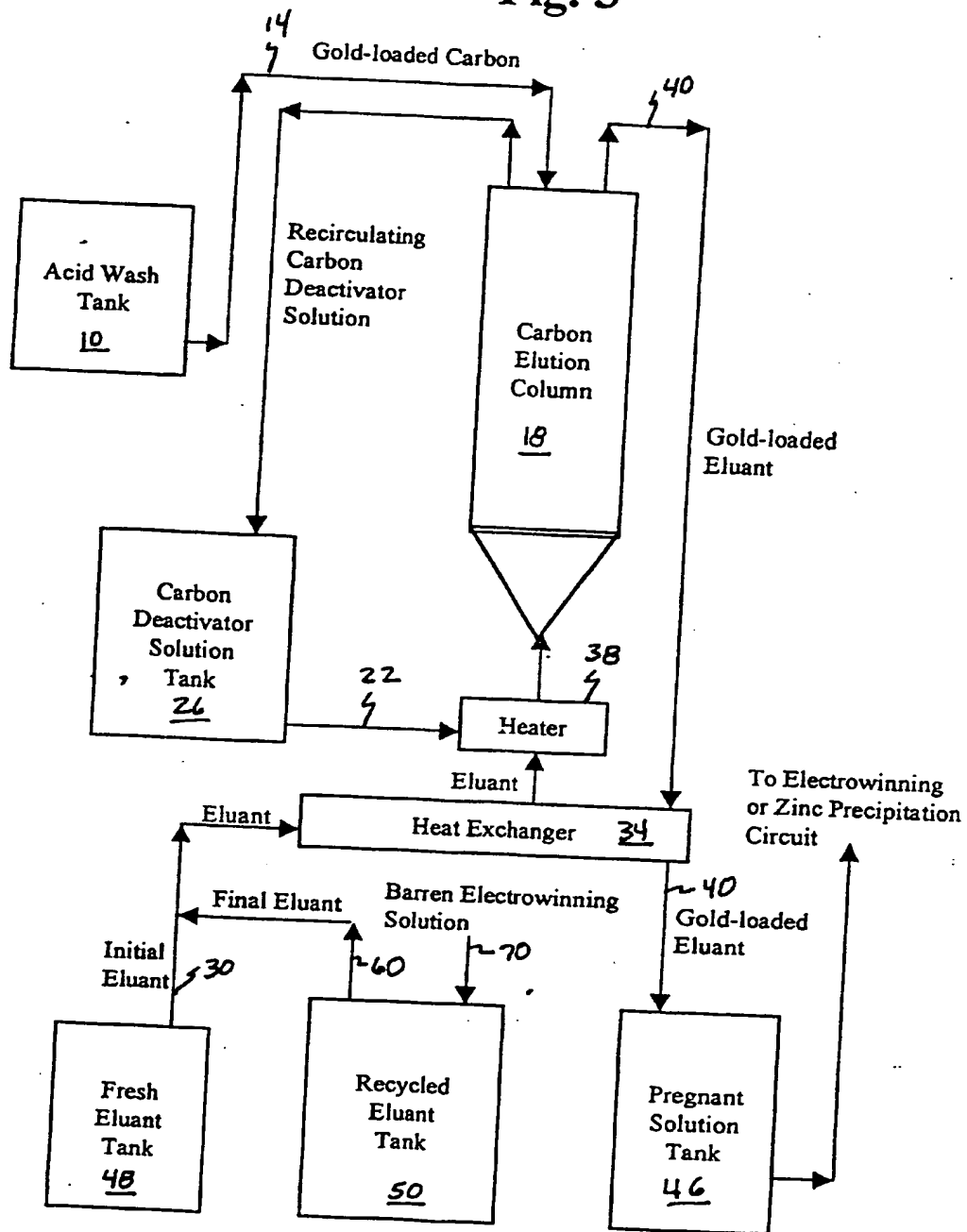


FIG. 4

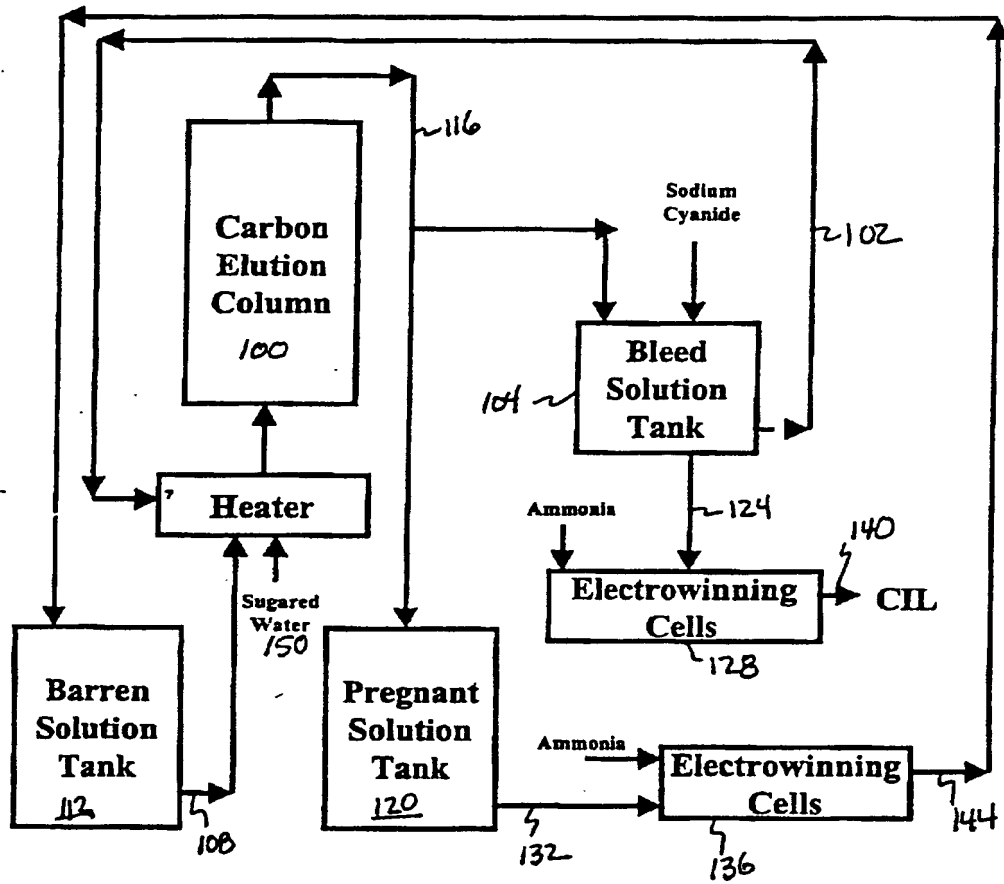


FIG. 5

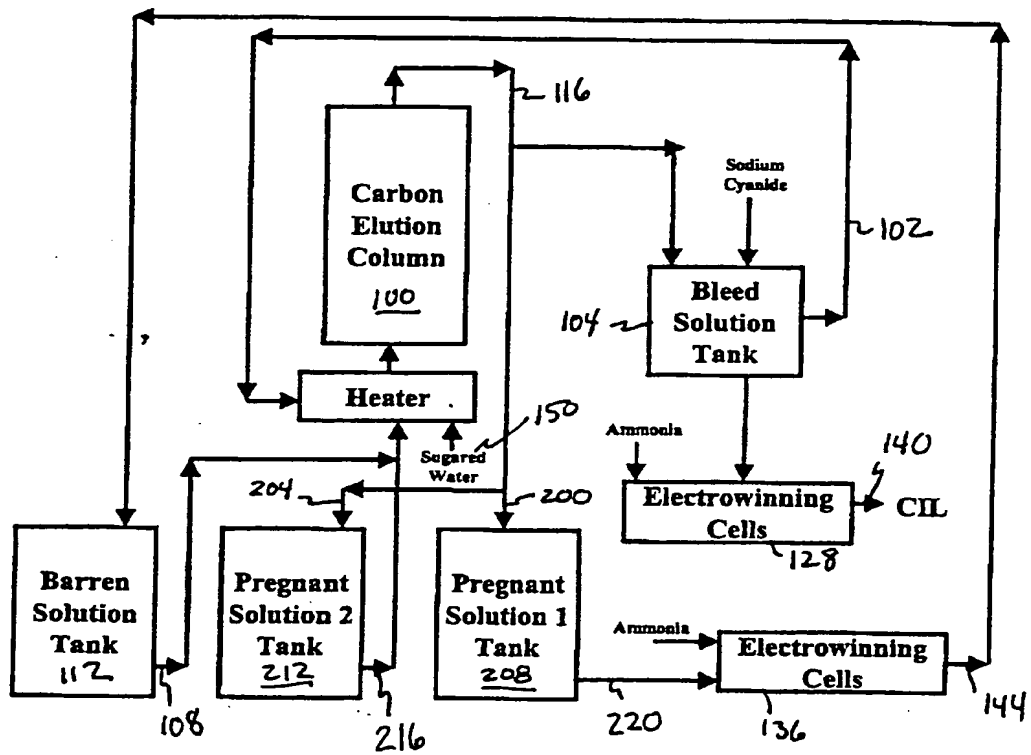


FIG. 6

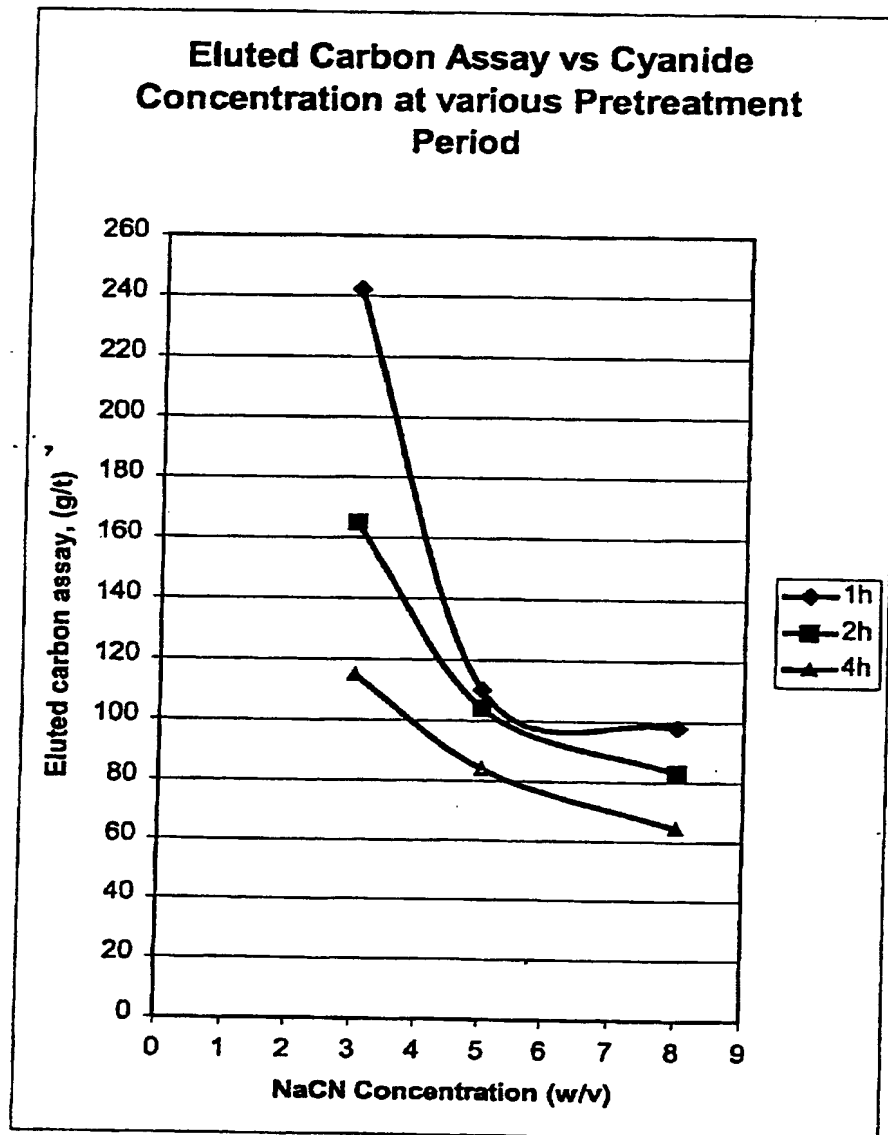
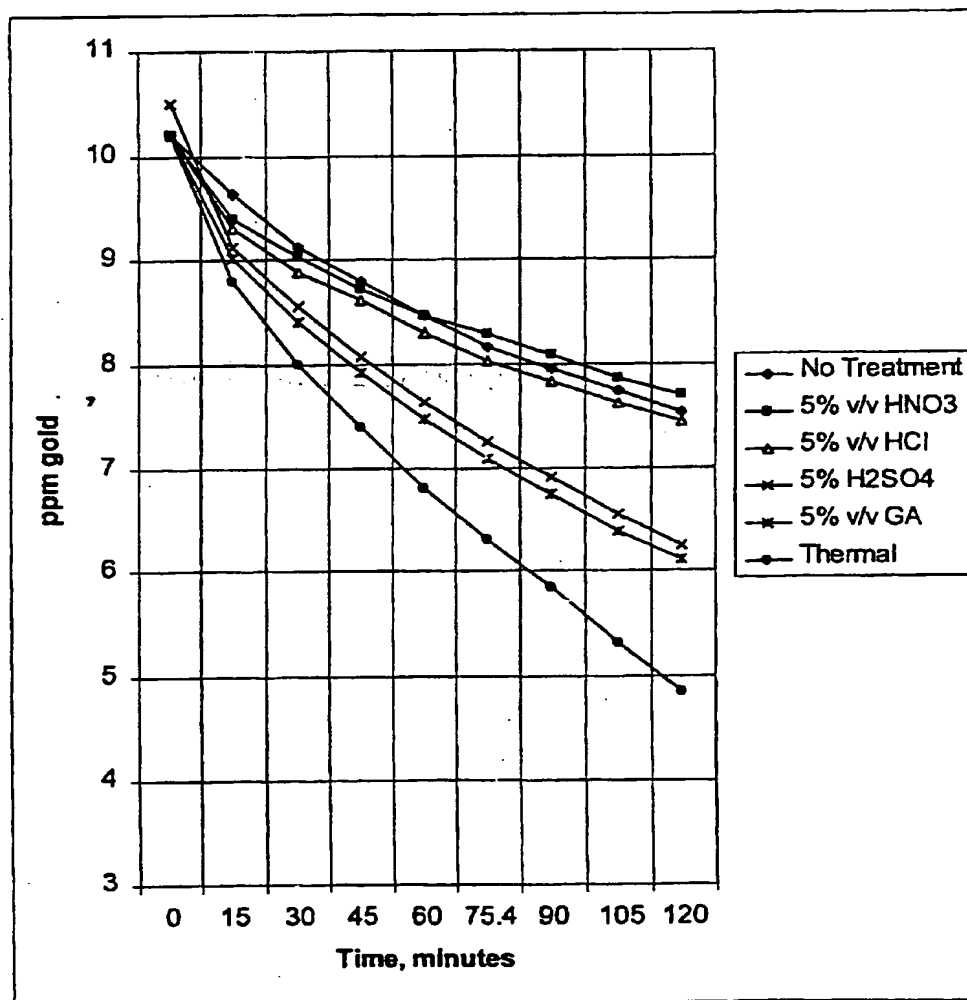


FIG. 7



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